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Bohart et al.

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(54) **BRUSH ASSEMBLY FOR DYNAMOELECTRIC MACHINE**

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Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

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(52) **U.S. Cl.** **310/239**; 310/242; 310/245; 310/246; 310/249

(58) **Field of Search** 310/239, 246, 310/240, 242, 245, 251, 252, 253, 244, 249

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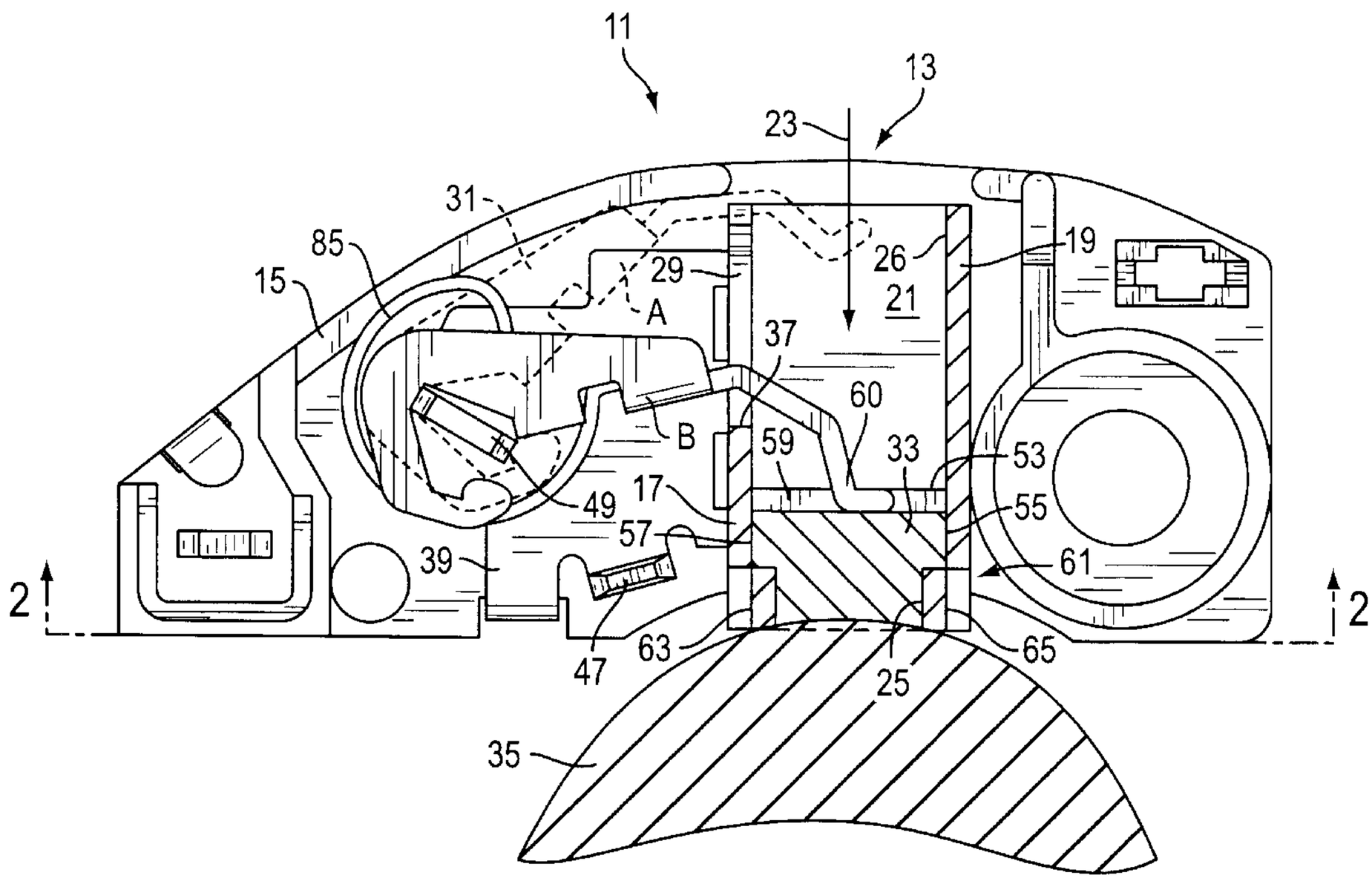
(57) **ABSTRACT**

A brush assembly preferably for a universal motor comprises a tubular brush holder **13**, a carbon brush **33**, an arm **31** for biasing the brush and a spring **85** for biasing the arm. The brush is slidably mounted in the cavity **21** of the holder. A stop **61** is formed between the brush and the holder and has a disengaged position to permit travel of the brush partially through the inner end **25** of the holder and an engaged position to limit travel of the brush through the inner end **25** of the holder. The electrically conductive arm **31** is pivotally mounted on the support and extends through a slot **29** of the holder. A distal end **60** of the brush engages the outer end **53** of the brush and biases the brush **33** toward the inner end **25** of the cavity. The spring **85** is connected between the support **15** and the arm **31** for biasing the arm **31** into engagement with the brush **33**. The arm is spaced outwardly of the end of the slot to apply a bias to the brush when the stop is in an engaged position. As a result the brush, when worn out is firmly held between the arm and the stop to reduce degradation of the arm **33** and commutator **35**.

8 Claims, 5 Drawing Sheets



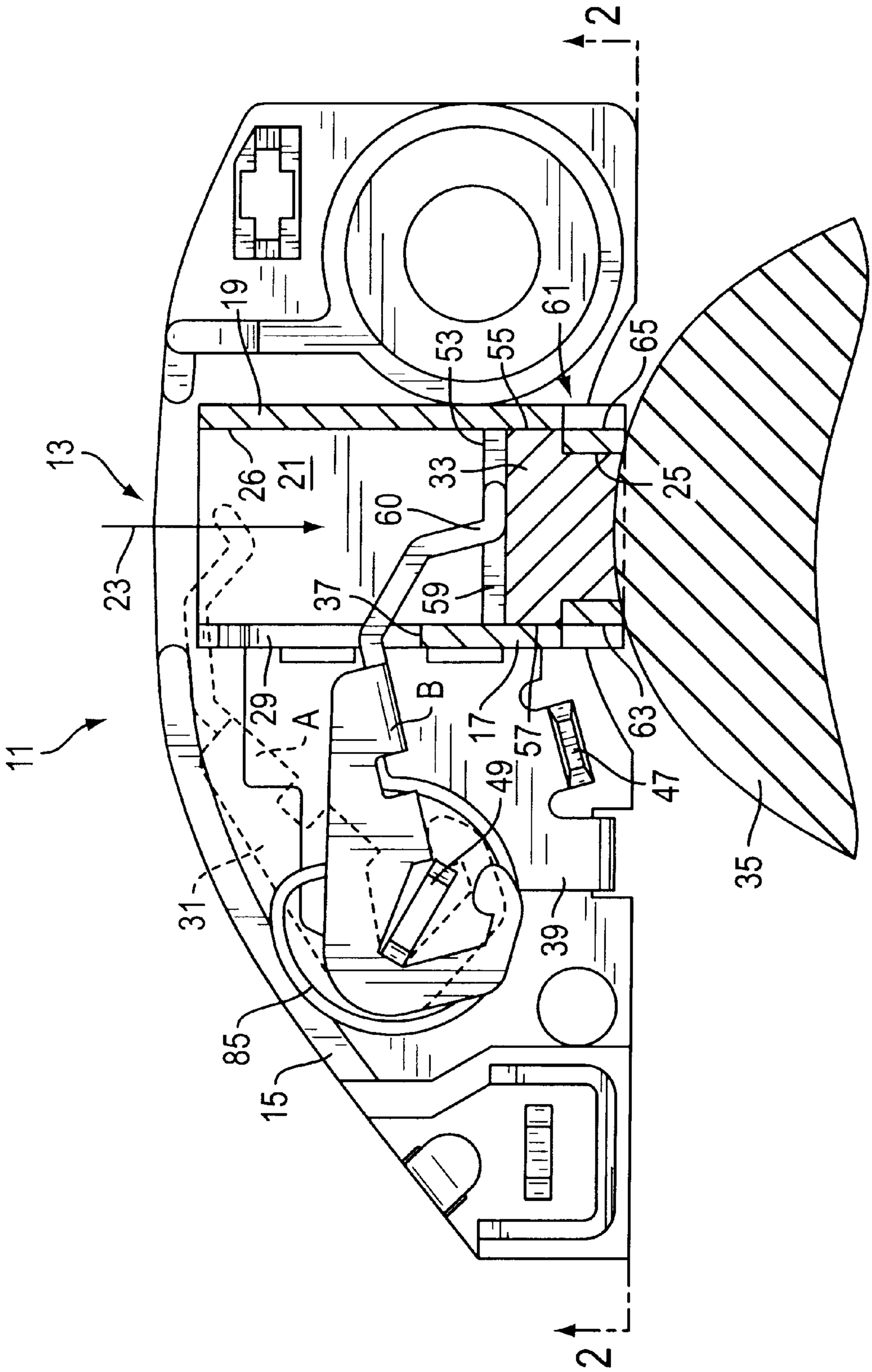

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FIG. 1

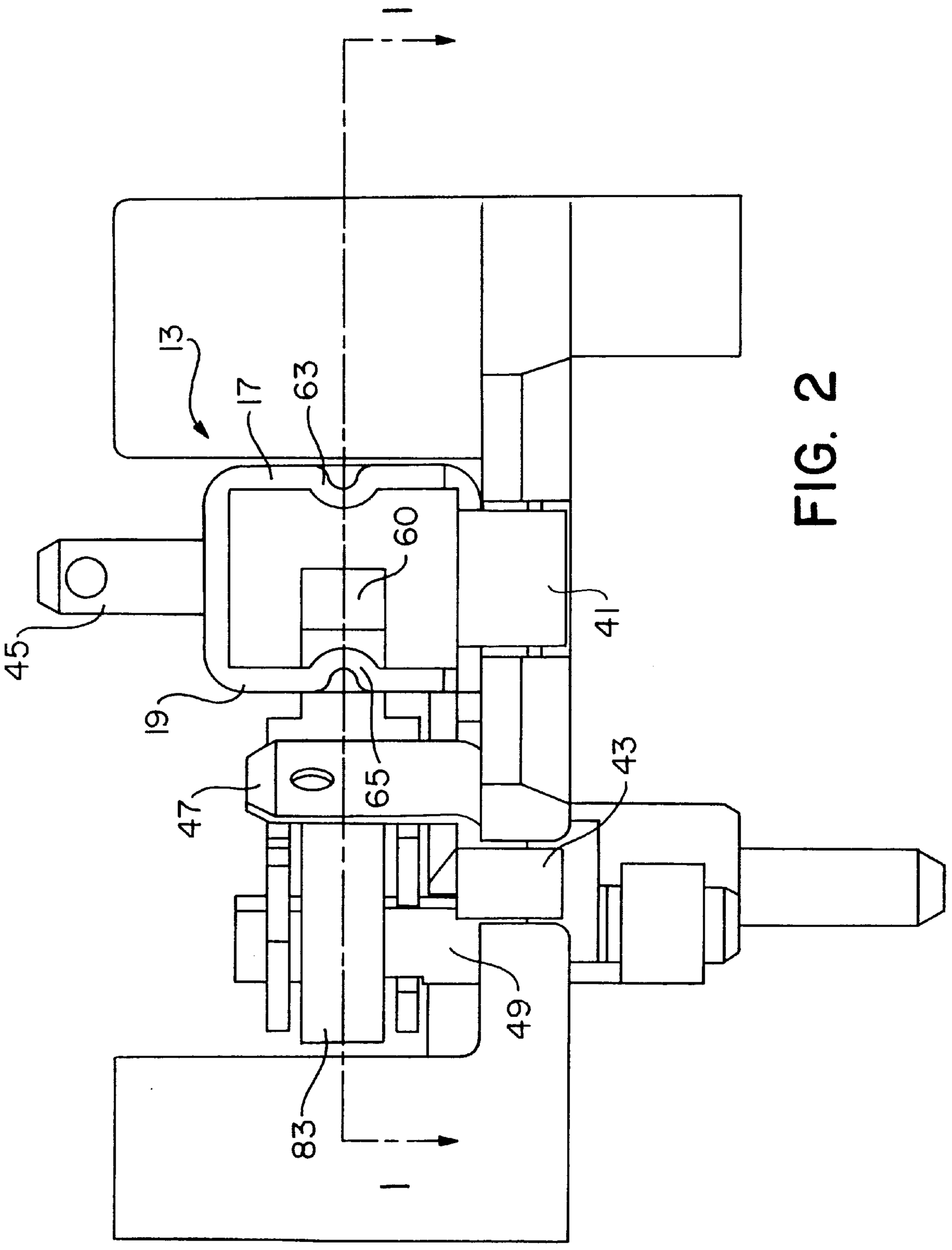


FIG. 2

FIG. 3

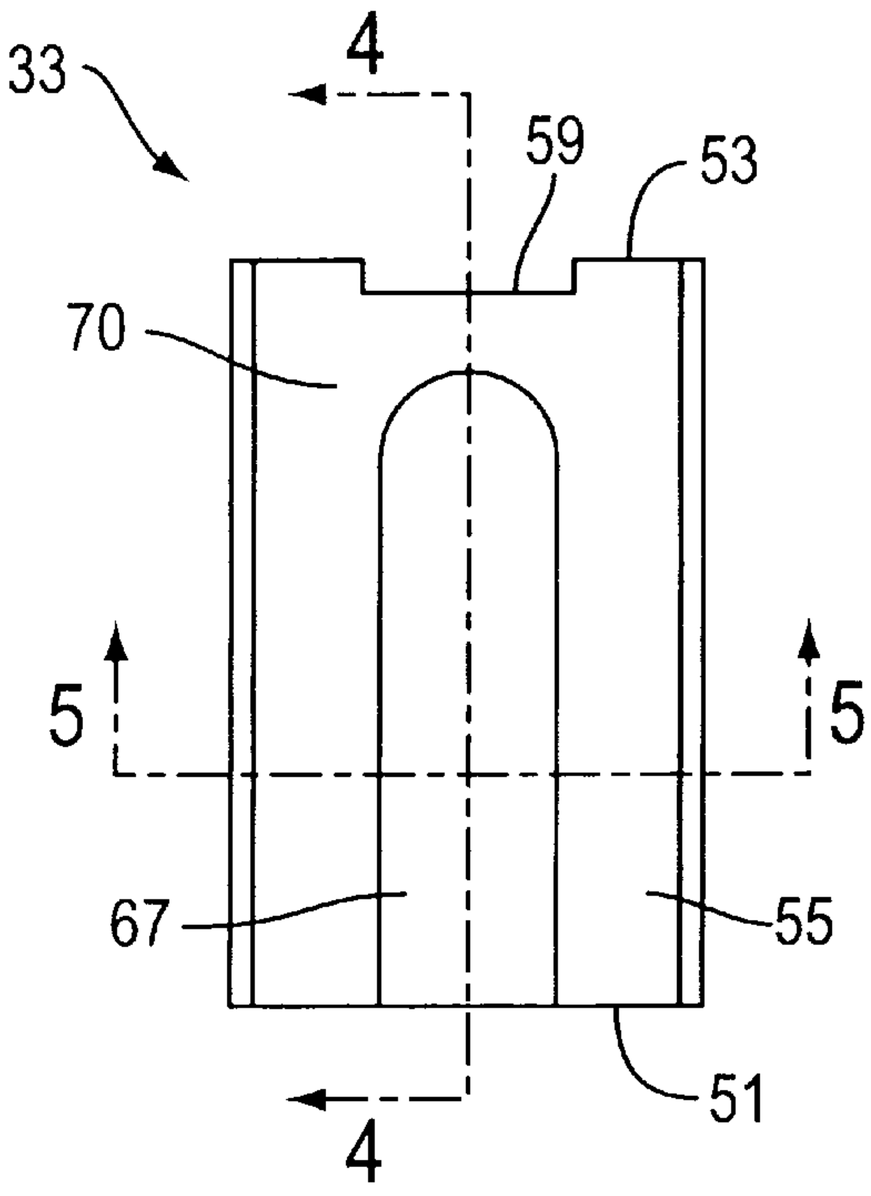


FIG. 4

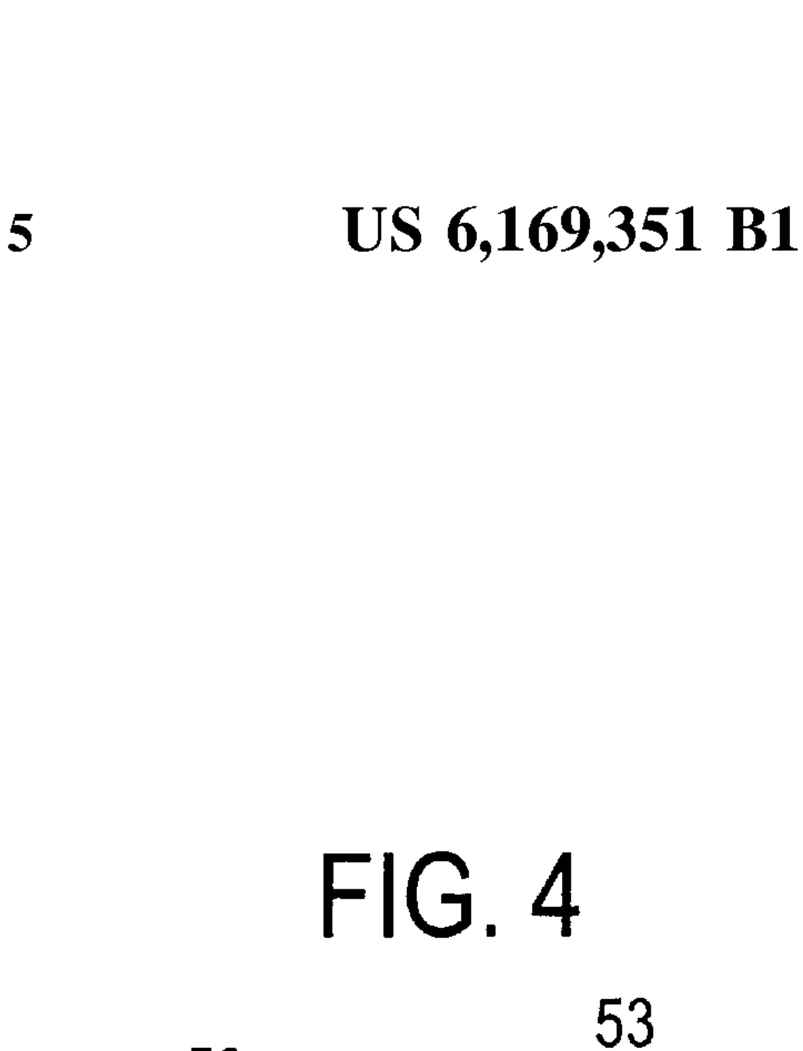
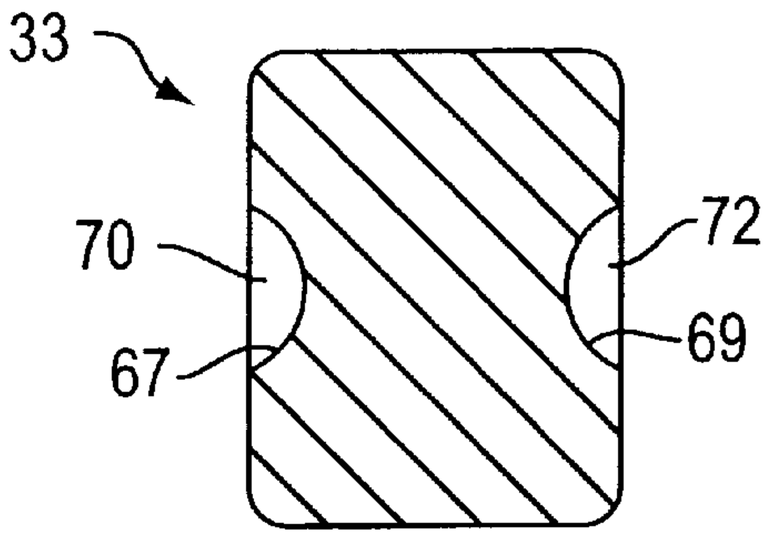


FIG. 5



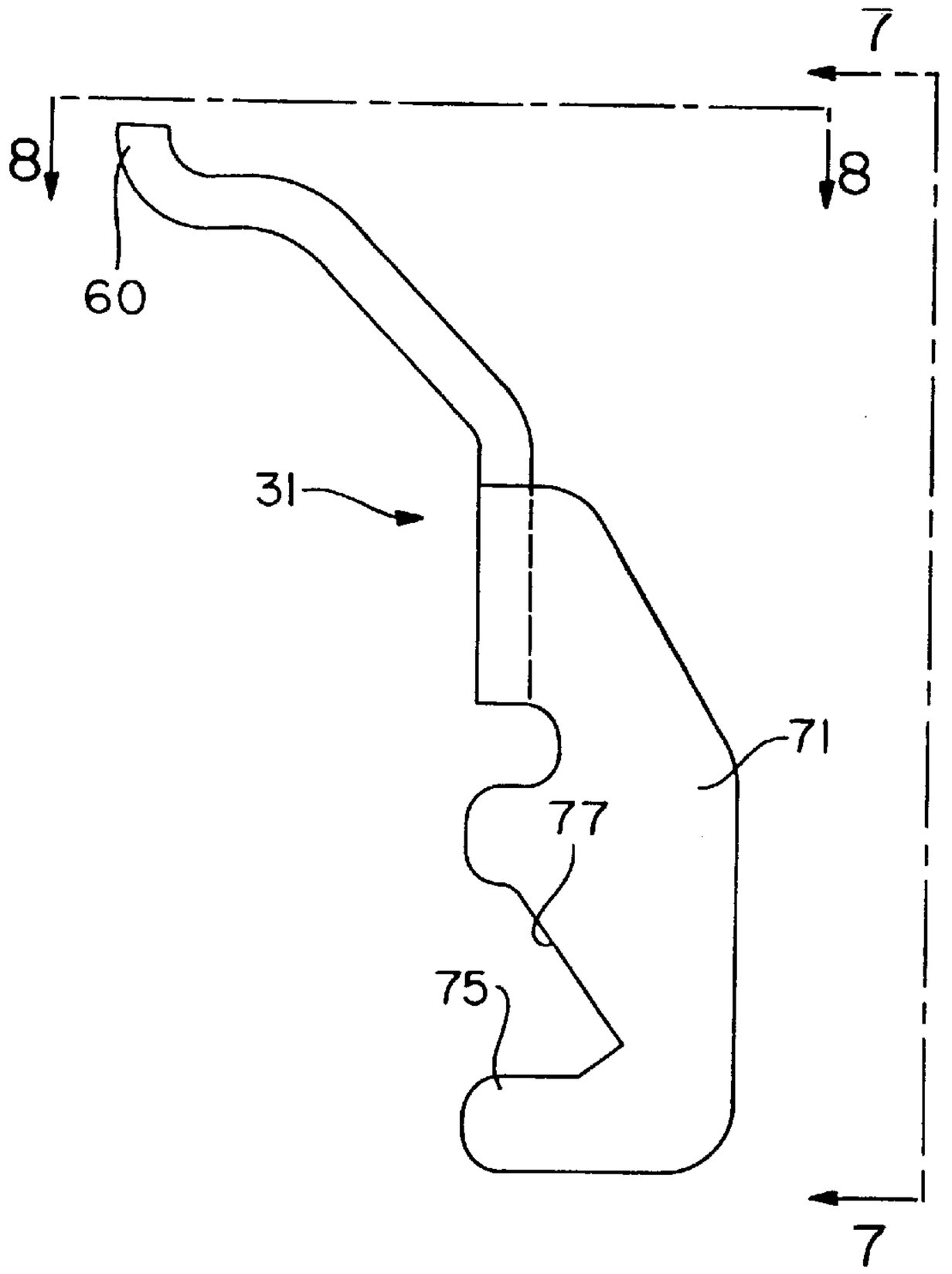


FIG. 6

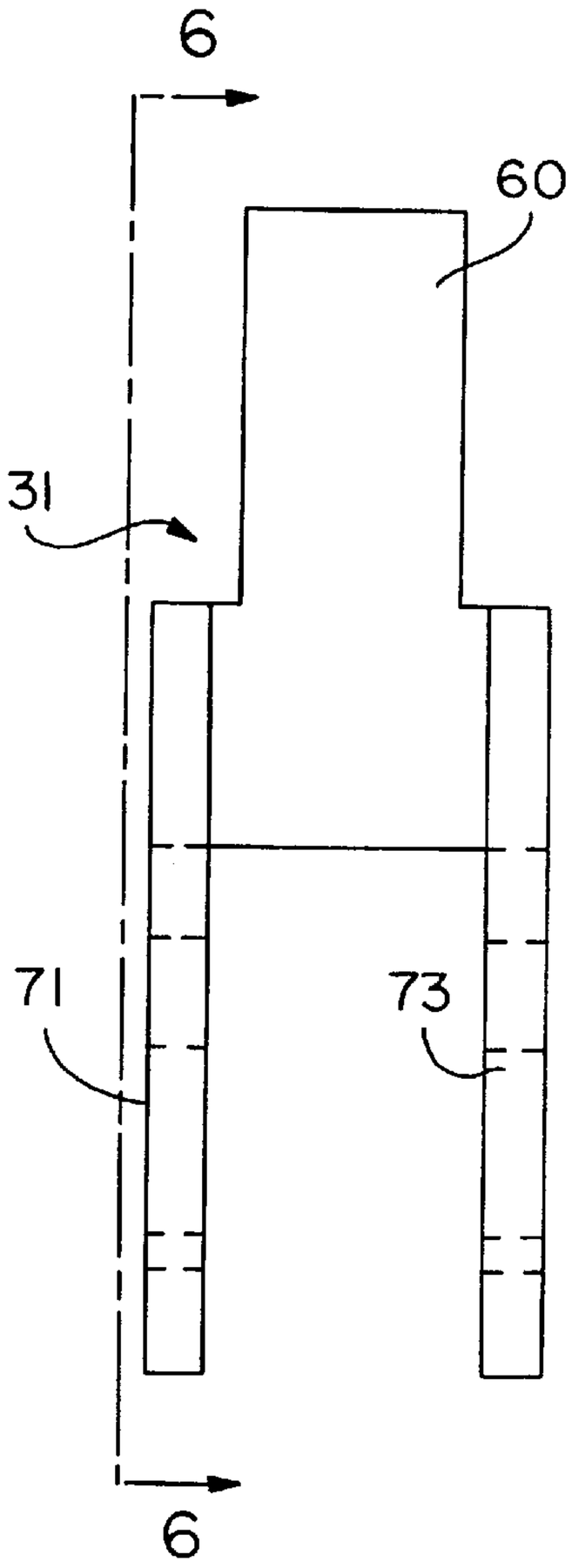


FIG. 7

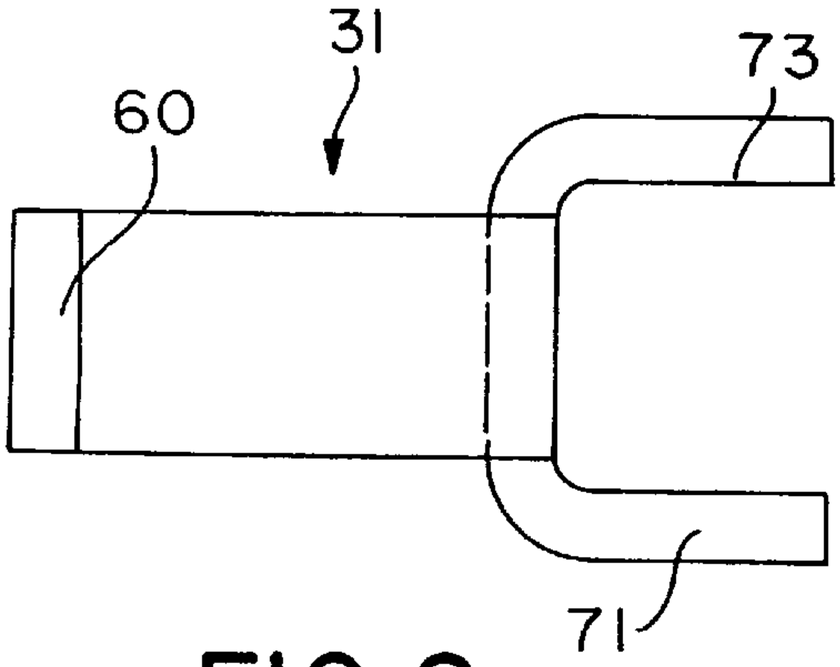


FIG. 8

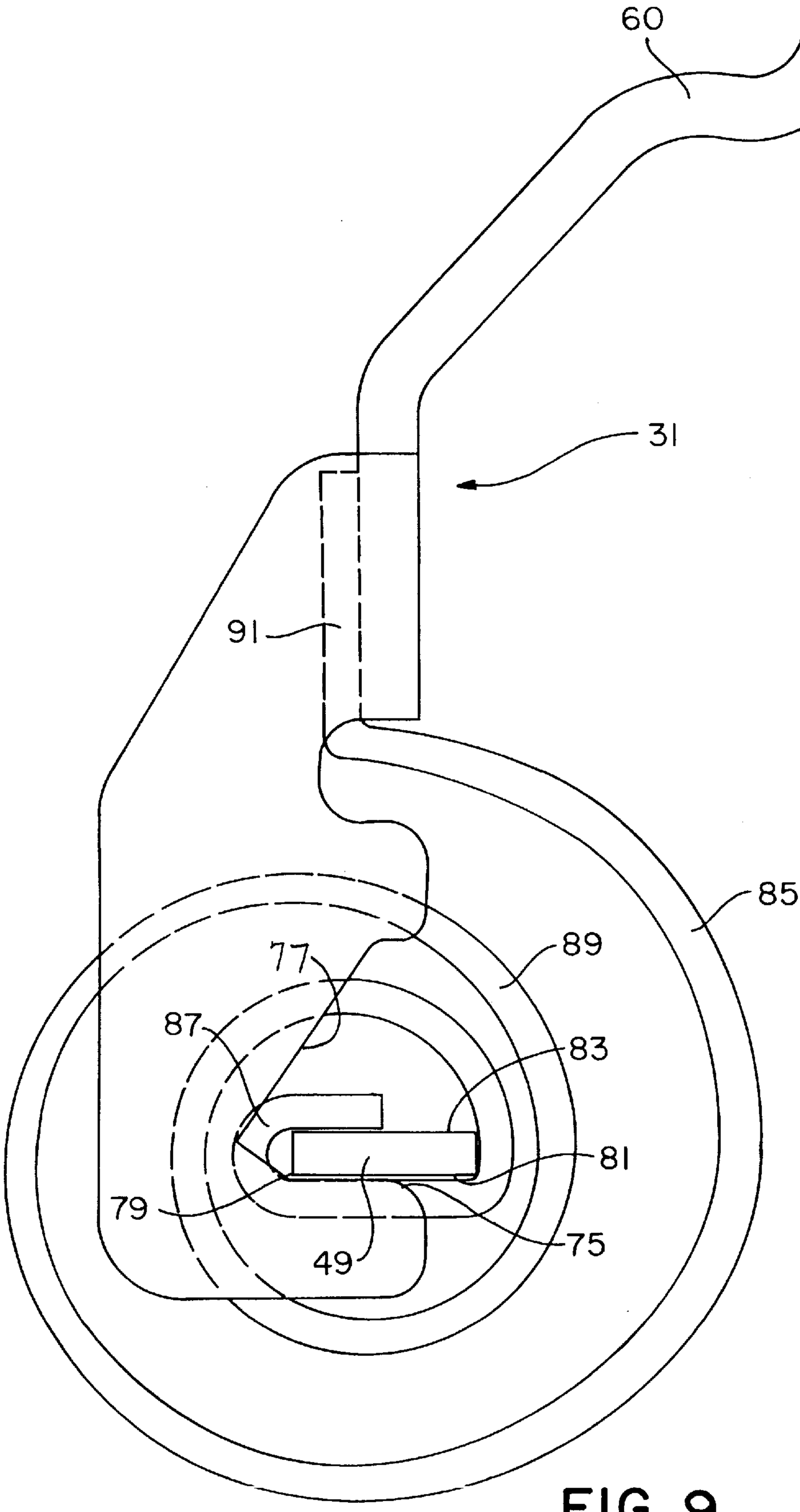


FIG. 9

BRUSH ASSEMBLY FOR DYNAMOELECTRIC MACHINE

FIELD OF THE INVENTION

This invention relates to a brush assembly for a dynamoelectric machine, preferably a universal fractional horsepower motor.

BACKGROUND OF THE INVENTION

In fractional horsepower universal motors commonly used for power tools and appliances, electrical contact is made to the rotating armature coils through the engagement of carbon brushes with a rotating commutator. Electrical contact from the brush to the motor circuit may be provided through a shunt wire embedded in the brush or through a spring biased arm engaged with the brush. The brushes, which are made carbon, are softer than the commutator and are worn away. The brush is typically slidably mounted in a holder and is biased by a spring or a spring biased arm toward the commutator to maintain electrical contact as the brush wears with use of the motor. Typically, for cost and simplicity, there is no specific means to identify when the brush is worn and should be replaced. The need for replacement is typically identified by the user when the tool stops working. This method for detecting when the brushes should be replaced has led to some significant problems. The travel of the spring or arm must be limited when the brush is worn to prevent contact of the arm or spring with the commutator which would damage the commutator. In addition if a brush with a shunt wire is used, the travel of the brush must be limited to prevent engagement between the shunt wire embedded in the brush and the commutator. Use of a shunt wire thus reduces the usable length of the brush because of the presence of the wire within a portion of the brush.

Shunted brushes have other disadvantages compared to shuntless brushes including higher manufacturing cost, high operating temperature and lower reliability. The manufacturing cost is higher because of the cost of forming the brush with the shunt wire embedded. A shunted brush has a high operating temperature because the shunt wire is normally electrically insulated and is therefore not easily cooled. Heat buildup increases the resistance of the brush assembly and therefore increases electrical losses. The shunted brushes have lower reliability because the wire is subject to snagging during assembly and operation of the motor.

To extend brush life and to mitigate the other disadvantages, shuntless brushes are commonly used for some applications. However, in the development of shuntless brushes, damage to the brush has been observed as the brush reaches an end of life condition. Such problems have been found to occur particularly in high current power tool motor applications having ratings of 6 to 8 amps. Thus there is a need to develop a shuntless brush assembly that is less subject to damage at the end of life of the brush.

SUMMARY OF THE INVENTION

According to the present invention a brush assembly comprises a tubular brush holder, a carbon brush, an arm for biasing the brush and a spring for biasing the arm. The holder has a cavity extending in a first direction, defined by the sidewalls of the holder and having an inner and outer open ends. The brush is slidably mounted in the cavity of the holder. A stop is formed between the brush and the holder and has a disengaged position to permit travel of the brush partially through the inner end of the holder and an engaged position to limit travel of the brush through the inner end of the holder. The electrically conductive arm is pivotally mounted on the support and extends through a slot of the holder. A distal end of the arm engages the outer end of the brush and biases the brush toward the inner end of the cavity. The spring is connected between the support and the arm for biasing the arm into engagement with the brush.

A significant feature of the invention is that the arm is spaced outwardly of the end of the slot to apply a bias to the brush when the stop is in an engaged position. As a result the brush when worn out is firmly held between the arm and the stop. This has resulted in a reduction in degradation of the components of the brush assembly.

The stop is preferably constituted by first and second grooves formed respectively in first and second sidewalls of the brush and mating first and second ribs formed in sidewalls of the holder. The grooves extend from the inner end of the brush toward the outer end of the brush and slidably receive the ribs for guiding movement of the brush in the cavity of the holder as the brush wears. First and second end walls are formed, respectively, in the first and second grooves inwardly of the brush outer end. The stop engaged position is formed when the end walls of the grooves engage the ribs and limit travel of the brush through the inner end of the holder.

The arm is preferably connected to the support through a low friction pivot formed by a base of the arm pivotally biased against a sharp edge of a post integrally formed with the holder.

The spring provides essentially a constant bias on the brush through the travel of arm as the brush is worn. The spring preferably has one end anchored to the post, an intermediate section coiled about the post and the other end engaged with the midsection of the arm.

Other aspects and advantages of the invention will be apparent from the detailed description of the preferred embodiment, the appended claims and the accompanying drawings or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings which are incorporated in, and constitute a part of, this specification illustrate one embodiment of the invention and together with the description serve to explain the principles of the invention.

FIG. **1** is a top plan view of a brush assembly in accordance with a preferred embodiment of the present invention.

FIG. **2** is an elevational view taken along line **2**—**2** of FIG. **1** except that the brush has been removed from the holder.

FIG. **3** is a side elevational view of a brush for use in the brush assembly shown in FIG. **1**. in accordance with a preferred embodiment of the present invention.

FIG. **4** is an axial cross sectional view taken along line **4**—**4** of FIG. **3**.

FIG. **5** is a transverse cross sectional view taken along line **5**—**5** of FIG. **3**.

FIG. **6** is a top plan view of the arm for biasing the brush in the brush assembly of FIG. **1**.

FIG. **7** is side elevational view of the arm of FIG. **1** taken along line **7**—**7** of FIG. **6**.

FIG. **8** is an end elevational view of the arm of FIG. **1** taken along line **8**—**8** of FIG. **6**.

FIG. **9** is a top plan fragmentary view of the arm, spring and post of the brush assembly of FIG. **1**. The arm, spring

and post are shown in the Position A corresponding to when an unworn brush is in the brush holder.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiment of the present invention is shown in FIGS. **1–9** and is a brush assembly **11** for fractional horsepower universal motors typically used in power tools and household appliances. The present invention will also have application to other types of motors and generators using commutators and brushes for making electrical connection to the windings of the armature.

According to the present invention shown best in FIGS. **1** and **2**, the brush assembly **11** comprises an electrically conductive tubular holder **13** fixed to a support. (In FIG. **2**, a brush is not shown in the holder.) The support is preferably formed of electrically insulating material and is preferably fixed relative to the stator of a motor. As will be explained below, the holder **13** provides one of the primary electrical connections between a brush **33** supported in the holder **13** and the motor stator (not shown). The holder **13** includes first and second sidewalls **17**, **19**. A cavity **21** extends in a first direction, is defined by the sidewalls **17**, **19** of the holder **13** and has an inner open end and an outer open ends **25**. A slot **29** is formed in the first sidewall of the holder **13** for receiving an arm **31** for biasing the brush **33** toward a commutator **35** of the motor. The slot **29** preferably has an inner end wall **37** which, except for the present invention as explained below, would normally engage the arm **31** and limit travel of the arm **31** toward the commutator **35** of the motor.

Preferably, the holder **13** is formed from a single brass plate **39** fixed to the support by a plurality of tabs **41**, **43** (two of which are shown in FIG. **2**). A first terminal **45** for connecting the holder **13** to the motor stator is formed in the plate **39** and extends perpendicular to the plane of support. A second terminal **47** (FIGS. **1**, **2**) for connection of brush shunt wire in an embodiment of the invention (not shown) using a shunted brush. This embodiment of the invention is desirable for motors in which increased suppression of EMI is required. A post **49** is also formed integrally with the plate **39** to form a conductive pivot for the electrically conductive arm **31** for biasing the brush **33** into engagement with the commutator **35** as will be explained below.

According to the present invention as shown in FIGS. **1** and **3–5**, the assembly **11** further comprises the brush **33** consisting essentially of carbon. The brush **33** is formed of a conventional composition of carbon particles with appropriate binder. The brush **33** is slidably mounted in the cavity **21** of the holder **13** and has inner and outer ends **51**, **53** and first and second opposed sidewalls **55**, **57** extending between the inner and outer ends **51**, **53**. Preferably, the brush **33** has a generally rectangular parallelepiped configuration with a transverse channel **59** in the outer end wall **53** for receiving a distal end **60** of the arm **31**. A secondary current path between the motor stator and the commutator **35** is through the engagement of the brush **33** with the sidewalls **17**, **19** of the holder **13**. As noted above the holder **13** is connected to the motor stator through the first terminal **45**.

According to the present invention as shown in FIGS. **1** and **3–5**, the assembly **11** further comprises a stop **61** formed between the brush **33** and the holder **13**. The stop **61** has a disengaged position to permit travel of the brush **33** partially through the inner end **25** of the holder **13** and has an engaged position to limit travel of the brush **33** through the inner end **25** of the holder **13**. Preferably, the stop **61** is formed by a first and second ribs **63**, **65** and first and second mating grooves **67**, **69**. The first and second ribs **63**, **65** are arcuate, extend axially and are formed in and projecting inwardly from the first and second sidewalls **17**, **19** of the holder **13**. The forming of ribs **63**, **65** integrally from the sidewalls **17**, **19** of the holder **13** contributes to the simplicity and low cost of the present invention.

The first and second grooves **67**, **69** are formed respectively in the first and second sidewalls **55**, **57** of the brush **33** and extend in the first direction **23**. The grooves **67**, **69** extend from the inner end **51** of the brush **33** toward the outer end **53** of the brush **33** and slidably receive the ribs **63**, **65** for guiding movement of the brush **33** in the cavity **21** of the holder **13** as the brush **33** wears. The grooves **67**, **69** are preferably arcuate in cross section to mate with the ribs **63**, **65** of the holder **13**. Other cross sectional shapes of the guides and grooves **67**, **69** can also be used. To reduce friction, the mating surfaces of the guides and grooves **67**, **69** should have the same shape. A significant feature of the invention is that the grooves **67**, **69** and end walls **70**, **72** are formed integrally in the carbon brush body. The elimination of additional parts to perform the guiding and stop ping functions of the brush **33** in the holder **13** increases the reliability and reduces the manufacturing cost.

Alternatively, the stop **61** may be formed by a single pair of mating grooves **67**, **69** and ribs **63**, **65** in lieu of the two pairs of mating grooves **67**, **69** and ribs **63**, **65**. Also, the piloting of the brush **33** in the holder **13** can be formed by a projection formed in the sidewall of the brush **33** and slidably engaged in a slot **29** in the holder **13**. Neither of these alternatives is shown.

According to the invention as shown in FIGS. **1**, **2** and **7–9**, the assembly **11** further comprises the electrically conductive arm **31** for biasing the brush **33** toward the inner end **25** of the cavity **21**. The arm **31** is pivotally mounted on the support, extends through the slot **29** of the holder **13** and is engaged with the outer end **53** of the brush **33**. Most significantly, the arm **31** applies a bias to the brush **33** when the stop **61** is in an engaged position. In the preferred embodiment, the distal end **60** of the arm **31** is spaced outwardly of the end wall **37** of the slot **29** to apply a bias to the brush **33** when the groove end walls **70**, **72** are engaged with the ribs **63**, **65** to prevent further inward movement of the brush **33**. Thus when the stop **61** is engaged corresponding to the end of the usable brush length, the remainder of the brush **33** is firmly held between the arm **31** and the ribs **63**, **65** of the holder **13**. This prevents the brush **33** from vibrating and arcing at the end of brush life thus protecting the brush assembly from degradation.

Preferably, the arm **31** further has a base formed by first and second legs **71**, **73**. Each leg **71**, **73** has angularly spaced sidewalls **75**, **77** located adjacent opposed sides **81**, **83** of the post **49** and pivotal about the post **49** through the angle formed between the angularly spaced sidewalls **75**, **77**. The arm **31** is pivotal on a sharp edge **79** of the post **49** to provide a low friction pivot. The arm **31** is not connected to the post **49** except through a spring **85** as will be explained below.

The arm **31** serves a number of purposes. First, the arm **31** retains the brush **33** in engagement with the commutator **35**. Second, the arm **31** provides an electrical current path between the brush **33** and the motor stators through the post **49** integrally formed on plate **39**. This path is supplemented by the current path between the brush **33** and the holder **13**. The arm/brush current path is particularly important, for example, when a commutator **35** is worn and causes the brush **33** to vibrate reducing the effectiveness of the brush/

holder current path. The use of parallel current paths and the avoidance of power losses are important in cordless power tools to extend the usable energy from a single charge of the battery pack. Third, the arm **31** thermally insulates the spring **85** from the brush **33**. Excessive heat will anneal the spring **85** and damage its spring constant. Arm **31** acts as a heat sink and heat radiator. Heat is eliminated from arm **31** by being supported in the air flow generated by a motor fan (not shown). Finally, the arm **31** provides an inertial load on the brush **33** to make the brush **33** less subject to vibration and arcing.

According the invention as shown in FIGS. **1** and **9**, the assembly **11** further comprises a spring **85** connected between the support and the arm **31** for biasing the arm **31** into engagement with the brush **33**. Preferably the spring **85** is a clock spring **85** to apply an approximately constant bias to the brush **33** through the full range of motion of the arm **31**. A clock spring **85** with a low spring constant is particularly suited for this application. The clock spring **85** has one end **87** connected to the post **49**, an intermediate section **89** encircled a number of times about the post **49** and a second end **91** connected to a central portion of the arm **31** for biasing the arm **31** tightly against the post **49** and toward the brush **33**. (In FIG. **1**, for clarity the intermediate section **89** of the spring **85** is largely omitted. The intermediate section **89** of the spring **85** has nine turns but in FIG. **9** is shown with a reduced number of turns for clarity.) As can be seen in FIG. **1**, the travel of arm **31** between positions A and B is a small percentage of the travel of spring **85** required to wrap the spring **85** about post **49** resulting in an approximately constant bias on the brush **33** throughout the life of the brush **33**. Tight engagement between the arm **31** and the post **49** is important to insure that good electrical contact is made. Alternatively, the spring **85** can be a coil spring or a torsion spring **85** connected between the support and the arm **31** and biasing the arm **31** into engagement with the brush **33**.

In operation, when a brush **33** is unworn the arm **31** is located in position A and biases the brush **33** in contact with the commutator **35**. In this position the ribs **63**, **65** in the holder **13** are located in the inner end of the grooves **67**, **69** corresponding to the stop **61** being located in the disengaged position. As the brush **33** is worn by engagement with commutator **35** during operation of the motor, the brush **33** becomes progressively shorter and continues to move toward the commutator **35** due to the bias applied by the arm **31**. Such movement continues until the ribs **63**, **65** of the holder **13** engage the end walls **70**, **72** of the grooves **67**, **69** corresponding to the stop **61** engaged position. With the stop **61** engaged, the arm **31** is located in position B and travel of the brush **33** through the inner end **25** of the holder **13** is no longer possible. In position B, the arm **31** is located outwardly from inner end of the slot **29**. As a result the brush **33** is firmly held between the arm **31** and the ribs **63**, **65** of the holder **13**.

One aspect of the present invention is that it has been discovered in the development of shuntless brush assemblies with an electrically conductive bias arm **31** that degradation of the commutator **35** and the arm **31** at the end of brush life can be significantly reduced. The degradation is believed to have been caused by vibration and looseness of the brush **33** at the end of brush life. The looseness occurred because the arm **31** engaged the slot **29** in the sidewall of the brush holder **13** and was limited in travel by engagement of the arm **31** with the end wall **37** of the slot **29**. As the brush **33** continued to wear the arm **31** was no longer able to bias the brush **33** tightly against the commutator **35**. Thus the brush **33** may have been subject to vibration and arcing between the brush **33** and arm **31** and between the brush **33** and commutator **35**. Thus one significant advantage of the present invention is that the brush **33** is held tightly between the arm **31** and the ribs **63**, **65** of the holder **13** when the brush **33** is worn out. As a result damage to the arm **31** and commutator **35** is reduced. If no specific means for identifying when the brush **33** is worn out, operation of the motor will cease when electrical contact between the brush **33** and commutator **35** is no longer possible. The worn brush **33** is then replaced by a new brush **33**. Because the worn brush **33** is replaced with less damage being incurred by the motor, life of the motor is increased.

Also there are other advantages result from the present invention. When using a shuntless brush according to the preferred embodiment the assembly **11** provides a low manufacturing cost, lower operating temperature and improved reliability.

Various modifications and variations can be made in a brush assembly according to the present invention without departing from the scope or spirit of the invention. Thus, the present invention is intended to cover these modifications and variations provided they come within the scope of the appending claims and their equivalents.

What is claimed is:

1. A brush holder assembly comprising:

a support;

a tubular holder, fixed to the support, comprising:

a first and second sidewalls extending a first direction and having a slot formed in the first sidewall, the slot having an inner end; and

a cavity extending in a first direction, defined by the sidewalls of the holder and having an inner and outer open ends;

a brush slidably mounted in the cavity of the holder;

a stop formed between the brush and the holder, having a disengaged position to permit travel of the brush partially through the inner end of the holder and having an engaged position to limit travel of the brush through the inner end of the holder;

an electrically conductive arm (1) pivotally mounted on the support, (2) extending through the slot of the holder, (3) engageable directly electrically with the outer end of the brush to provide direct electrical physical contact between the arm and the brush, (4) biasing the brush toward the inner end of the cavity and (5) spaced outwardly of the end of the slot to apply a bias to the brush when the stop is in an engaged position; and

a spring connected between the support and the arm for biasing the arm directly electrically into contact engagement with the brush.

2. The assembly of claim **1** wherein:

a post extends from the support, and

the spring is clock spring, has one end connected to the post, has an intermediate section encircled about the post and has a second end connected to the arm for biasing the arm toward the brush.

3. The assembly of claim **2** wherein the post has opposed sides and the arm further comprises a base with angularly spaced sidewalls, defining an angle formed therebetween, located adjacent the sides of the post; and the arm is pivotal about the post through the angle formed between the angularly spaced sidewalls.

4. The assembly of claim **1** wherein:

the stop is formed by first and second ribs on the holder and first and second mating grooves formed on the brush;

the ribs are formed on the first and second sidewalls of the holder;

the brush is formed with first and second sidewalls and an inner end;

the grooves are formed on the first and second sidewalls of the brush, extend from the inner end of the brush toward the outer end of the brush, and slidably receive the first and second ribs for guiding movement of the brush in the cavity of the holder as the brush wears.

5. The assembly of claim **1** wherein the brush is shuntless.

6. A brush holder assembly comprising:

a support;

a tubular holder, fixed to the support, comprising:

a first and second sidewalls extending a first direction and having a slot formed in the first sidewall, the slot having an inner end; and

a cavity extending in a first direction, defined by the sidewalls of the holder and having an inner and outer open ends;

a brush slidably mounted in the cavity of the holder;

a stop formed between the brush and the holder, having a disengaged position to permit travel of the brush partially through the inner end of the holder and having an engaged position to limit travel of the brush through the inner end of the holder;

an electrically conductive arm (1) pivotally mounted on the support, (2) extending through the slot of the holder, (3) engageable with the outer end of the brush, (4) biasing the brush toward the inner end of the cavity and (5) spaced outwardly of the end of the slot to apply a bias to the brush when the stop is in an engaged position;

a spring connected between the support and the arm for biasing the arm into engagement with the brush;

a post having opposed sides extends from the support;

the arm is formed with a base having angularly spaced sidewalls, defining an angle formed therebetween, located adjacent the sides of the post;

the arm is pivotal about the post through the angle formed between the angularly spaced sidewalls; and

the spring is a clock spring having one end connected to the post, an intermediate section encircled about the post and has a second end connected to the arm for biasing the arm toward the brush.

7. A brush holder assembly comprising:

a support;

a tubular holder, fixed to the support, comprising:

a first and second sidewalls extending a first direction and having a slot formed in the first sidewall, the slot having an inner end; and

a cavity extending in a first direction, defined by the sidewalls of the holder and having an inner and outer open ends;

a brush slidably mounted in the cavity of the holder;

a stop formed between the brush and the holder, having a disengaged position to permit travel of the brush partially through the inner end of the holder and having an engaged position to limit travel of the brush through the inner end of the holder;

an electrically conductive arm (1) pivotally mounted on the support, (2) extending through the slot of the holder, (3) engageable with the outer end of the brush, (4) biasing the brush toward the inner end of the cavity and (5) spaced outwardly of the end of the slot to apply a bias to the brush when the stop is in an engaged position;

a spring connected between the support and the arm for biasing the arm into engagement with the brush;

a post having opposed sides extends from the support; and

the arm is formed with a base having angularly spaced sidewalls located adjacent the sides of the post.

8. The assembly of claim **7** wherein:

the arm is pivotal about the post through the angle formed between the angularly spaced sidewalls.

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